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# BILINGUAL MEN BUT NOT WOMEN DISPLAY LESS LEFT EAR BUT NOT RIGHT EAR ACCURACY DURING DICHOTIC LISTENING COMPARED TO MONOLINGUALS

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*Thirty monolingual university men and women and 33 bilingual university men and women who had learned English after 5 years of age were administered Roberts' Dichotic Word Listening Test. The bilingual men committed twice the numbers of errors for words presented to the left ear but not to the right ear or to both ears when compared to the bilingual women, the monolingual men, or the monolingual women. The latter three groups did not differ significantly from each other. This interaction between sex and language history explained about 16% of the variance in the numbers of errors for the left ear. The results are related to other studies that showed men who acquired English after the age of 5 years exhibited a relative weakness for verbal memory but not for figural memory compared to bilingual women or monolingual men and women. Implications for the relative accuracies of verbal memory are considered.*

**Keywords** bilingualism, dichotic word listening, language, left ear, sex differences, verbal memory

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We have shown that bilingual men but not bilingual women display a relative weakness for verbal memory but not figural memory compared to monolinguals (Makarec & Persinger, 1993). Both the immediate and the delayed verbal memory for men who had been fluent in another language other than English before 6 years of age contained 20% to 50% less detail than men who were only fluent in English. On the other hand, scores for the immediate and delayed verbal memory of bilingual women and monolingual women did not differ from each other and were comparable to those of monolingual men.

These results were consistent with the results of several studies indicating that the acquisition of more than one language interferes with the execution of either one or both (Albert & Obler, 1978; Furtado & Webster, 1991). We had suggested that the attenuated verbal proficiency for bilingual men but not bilingual women could be related to the weak, but normal, delay in development within the left hemisphere of right-handed men (Geschwind & Galaburda, 1985) and the attenuated interhemispheric electrical coherence for men compared to women (Corsi-Cabrera, Herrera, & Malvido, 1989).

Kimura's (1987) demonstration that the spatial localization of language processing within the male adult hemisphere is more than in the normal female adult brain would support a receptive basis to this bilingual anomaly. We reasoned that if reducing efficiency in linguistic processing due to marginally less interhemispheric coherence and marginally less intrinsic proficiency for receptive language for men (in general) were additive, bilingual men who acquired the second (English) language after age 5 years of age should display more errors for words presented to the left ear during binaural (dichotic) word listening.

The rationale for this hypothesis is that relative decreases in reciprocal interactions between the two hemispheres after about 5 years of age would exert a statistical influence upon the coherence between the two hemispheres. Whereas electroencephalographic activity asymptotes to within adult levels around the age of 5 years, the right hemisphere reaches this level around the age of 10 years. Consequently the total capacity for the precision of intercalation for linguistic information acquired after age 5 should be less particularly in brains that are already marginally less coherent electrically, such as in men.

## METHODS

### Subjects

A total of 31 men and 32 women served as subjects; the mean and standard deviations for their ages were 21.4 years and 3.1 years, respectively. All subjects preferred their right hand and were enrolled in first year psychology courses over three consecutive years. To discern language history, subjects were asked to report if they first learned English before or after (usually when they began formal schooling) the age of 5 years. All of the subjects ($n$ = 33) who reported that English was their second language were recruited into this study. The first language for 28 of these subjects was French. The remaining 30 subjects were monolingual and were selected (initially $n$ = 33) randomly from the same classes. They did not speak a second language. Whereas all of the bilingual subjects volunteered and reported for testing three of the monolingual subjects did not.

### Procedure

Each subject was tested individually. The Roberts' (Roberts et al., 1994) Dichotic Word Listening Test (Auditec, St. Louis, MO, USA) was administered through stereo headphones (Koss TD60) that were attached to a Sony CFF920 tape recorder. The first 20 trials consisted of monaural practice words (10 words randomly presented to each ear). They were used to ensure appropriate set, understanding of the task, and auditory acuity. The subsequent 60 trials were dichotic word presentations. The total numbers of errors for the left ear only, right ear only, and both ears were measured.

Two way analyses of variance as a function of linguistic history (monolingual vs bilingual) and sex (men, women) were completed for the numbers of errors: 1) during monaural listening, 2) for words presented the left ear only, 3) for words presented to the right ear only, and 4) for words presented to both ears. To discern potential asymmetry and to accommodate the role of individual differences, the left-right ratio was calculated by dividing the numbers of errors for the left ear+1 by the numbers of errors for the right ear +1. The

integer was added to remove zero scores from the denominator. All analyses employed SPSS software on a VAX 4000 computer.

## RESULTS

The means and standard deviations for the numbers of errors (of 60 presentations) during dichotic listening for the right ear, left ear, and both ears for men and women who were either bilingual or monolingual are presented in Table 1. The numbers of errors for practice words, presented monaurally (of 10 presentations), are also shown. Two way analyses of variance (all dfs = 1,59) as a function of sex (men vs women) or linguistic history (monolingual vs bilingual) for the accuracy of the right ear displayed no statistically significant main effects for sex ($F = 2.05$, $p > .05$) or language history ($F = .01$, $p > .05$). The interaction between language history and sex was also not significant ($F = 2.10$, $p > .05$) statistically.

However the analysis of variance demonstrated a statistically significant interaction ($F = 7.59$, $p < .01$) between sex and language, as well as statistically significant differences between men and women ($F = 12.45$, $p < .01$; eta-squared = 16%) and language ($F = 7.59$, $p < .01$; eta-squared = 6%) for the numbers of errors

**TABLE 1.** Numbers of errors for practice words presented monaurally and words presented dichotically to the left ear, right ear, or both ears for men and women who were monolingual or bilingual

| | *Women* | | | | *Men* | | | |
|---|---|---|---|---|---|---|---|---|
| *Sample size* | *Monolingual 14* | | *Bilingual 18* | | *Monolingual 16* | | *Bilingual 15* | |
| *Measure* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Monaural | .9 | .8 | .9 | 1.1 | .9 | .7 | 1.0 | 1.3 |
| Right Ear | 4.5 | 2.8 | 3.5 | 2.8 | 2.5 | 1.9 | 3.4 | 2.8 |
| Left Ear | 4.6[a] | 2.8 | 4.4[a] | 2.6 | 5.3[a] | 3.8 | 10.8[b] | 6.4 |
| Both Ears | 0.9 | 1.0 | 1.8 | 1.5 | 0.8 | 1.4 | 1.8 | 2.3 |
| L-R ratio | 1.1[a] | 0.8 | 1.4 | 1.0 | 2.3 | 2.1 | 3.5 | 2.6 |

*Note.* The ratios of errors for left vs right ears are also presented.
*a* vs *b*; $p < .05$.

committed during presentations to the left ear. *Post hoc* analyses indicated that the primary source of this interaction was due to the greater number of errors displayed by the bilingual men compared to the other three groups who did not differ significantly from each other. The interaction, according to omega-squared estimates, accommodated 30% of the variance in the numbers of dichotic errors for the left ear.

There were no statistically significant differences (all $Fs < 1.00$, $p > .05$] between sex, language histories, or their interaction for the accuracy of practice (monaural) words. Although there were no significant sex differences for the numbers of errors for both ears, the bilingual subjects exhibited more of these errors than did the monolingual subjects ($F = 4.76$, $p < .05$; eta-squared = 7%). The interaction between gender and language was not significant statistically.

The ratios for the numbers of errors for the left ear divided by the errors for the right ear are also shown in Table 1. Two way analysis of variance indicated no statistically significant difference between language groups. However, both the monolingual and bilingual men exhibited more errors for the left ear relative to the right ear (higher ratio) compared to the women ($F = 12.33$, $p < .001$; eta-squared = 17%). The interaction between language history and gender was not significant statistically ($F = 1.21$, $p > .05$).

A three-way analysis of variance with one level repeated (left, right ear) and two not repeated (sex, language) showed a statistically significant interaction [$F(1,59) = 7.19$, $p = .01$; eta-squared = 11%] between sex and language history for the combination of errors for both ears. The *post hoc* analysis indicated that the bilingual males committed more errors for both ears compared to the other three groups who did not differ significantly from each other. However, the three-way interaction between sex, ear and linguistic background ($F = 3.46$, $p = .05$; partial eta-squared = 6%) reiterated the specific deficit for the left ear compared to the right ear for the bilingual males compared to the other three groups.

More errors were committed for words presented to the left ear for all groups compared to the words presented to the right ear ($F = 29.73$, $p < .001$; partial eta-squared = 34%). The interaction between sex and ear ($F = 20.29$, $p < .001$; partial eta-squared = 26%) was due, according to *post hoc* *t*-test comparisons, to the greater numbers of

errors committed by men for the left ear compared to the right ear [$t(31) = 5.44$, $p < .001$] compared to the women who did not display this discrepancy [$t(35) = 1.24$, $p > .05$]. The correlations (r) between the numbers of errors for the left and right ears for the men and women were .39 ($p < .05$) and .54 ($p < .001$), respectively.

Both the monolingual men [$t(16) = 2.88$, $p < .01$, $r = .21$, $p > .05$] and the bilingual men [$t(15) = 4.88$, $p < .001$; $r = 0.42$] displayed more errors for the left ear compared to the right ear. These discrepancies were not apparent for the monolingual women [$t(14) = .09$, $p > .05$; $r = 0.42$] or the bilingual women [$t(18) = 1.35$, $p > .05$; $r = .51$]. The significant interaction between language history and ear ($F = 7.11$, $p = .01$) was due to the greater numbers of errors for the left ear compared to the right for the bilingual subjects compared to the monolinguals. However, this interaction was primarily due to the contributions from the bilingual men.

## DISCUSSION

The results of this experiment showed that normal university men who acquired English after 5 years of age reported about twice the numbers of errors during dichotic word listening for the *left* ear relative to bilingual women or monolingual men or women who did not differ significantly from each other. This statistically significant anistropic effect, specific to bilingual men, was not observed for the numbers of errors for words presented to the right ear or to both ears simultaneously.

These results are consistent with our previous experiment (Makarec & Persinger, 1993). Bilingual men, who had been fluent in a language other the English before 6 years of age, could reconstruct narratives, either immediately or after 30 min, with 20% to 50% less details than the reconstructions by either bilingual women or monolingual men and women who did not differ significantly from each other. This relative weakness for bilingual men was specific to verbal memory and not to figural memory.

One possible explanation of the results of both studies is that the lower verbal fluency of men relative to women is reflective of a general weakness in language processing. This effect is simply

enhanced by another language acquired after approximately 5 years of age. A primary source of this weakness may involve less efficient processing of the linguistic, affective components from the right hemisphere into left hemispheric processing. Whether or not twice the numbers of errors, for example 10 per 60 pairs of words vs 5 per 60 pairs of word, for the left ear could account for the 20% to 50% less accurate details noted for verbal memory (Makarec & Persinger, 1993) must still be quantitatively determined by direct experiment.

We have assumed the increased errors committed for words presented to the left ear reflects an altered proficiency of the rate or type of processing within the neural pathways between the right temporal lobe and the left temporal lobe. Consequently, the relevance of this doubled incidence of errors within natural settings might be mild increases in the alterations of the contributions of the properties of the right temporal lobe to the experience and consolidation of spoken words and sentences. This assumption is contingent upon the validity of the argument that the right temporal lobe contributes more affective than categorical content to the experience of words.

In another study (O'Gorman & Persinger, 1998) employing monolingual university men who reported a right-handed preference, we found that the numbers of interpretational variations (whereby inferences were remembered rather than verbatim details) were directly related to the dichotic proficiency for the left ear only. In that study, the subjects were asked to reconstruct a 5-min narrative with multiple emotional themes and ambiguities one week after they had heard the story only once. We reanalyzed that data after dichotomizing the group into men ($n$ = 11) who had committed 5 or fewer errors for the left ear during dichotic word listening and men ($n$ = 6) who had committed more than 6 (range 6 to 12) errors for the left ear.

Compared to the subjects who committed less than 5 errors for the left ear (for the same dichotic word listening task employed in the present study), those men who committed more errors reported about one-third the number of recollections [$F(1,15) = 4.95$, $p < .05$; eta-squared = .24]. For the men with the greater numbers of left ear errors the mean and the standard deviation for the percentage

of recollections that were false or inferences of the story were 37 and 14, respectively, while these values for the men with less than 6 errors were 22 and 12 [$F(1,15) = 5.01$, $p < .05$; eta-squared = .25]. This effect size indicated that approximately one-quarter of the variance in the proportion of inferences or intrusive (false) errors could be explained by the relative accuracy of the left ear (and presumably the right temporal lobe) during dichotic word processing.

Interpretational variations during reconstructions of complex narratives would typically be scored as erroneous when verbatim memory is employed as the exclusive criterion for accuracy. Suppose the actual statement was "Billy didn't say anything and stared out of the window" but the later reconstruction was "the boy was looking out the window because he was sick and felt bad." This "memory" could be considered erroneous when compared to the original statement. The degree to which this inference, incorporated within the memory, is valid cannot be determined. Yet in some instances the "memory" might be considered as sufficiently approximate to be acceptable.

Such variations may have been responsible for the attenuated scores for verbal memory for the bilingual men reported by Makarec and Persinger (1993). From this perspective, the brains of men, particularly bilingual men, with less proficiency for transfer of verbal information from the right into the left hemisphere would be more prone to store the mild variations in the affective dimensions of words and their inferences as components of the experience that is later reconstructed and labeled as a memory. From a less pejorative perspective, this "statistical variability" in rote recreation might also increase the capacity for creativity and imaginative extrapolation in contexts where rote memories and very precise accuracy were not essential. Such variability would be less than optimal in forensic settings where precise reconstructions often affect people's lives.

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